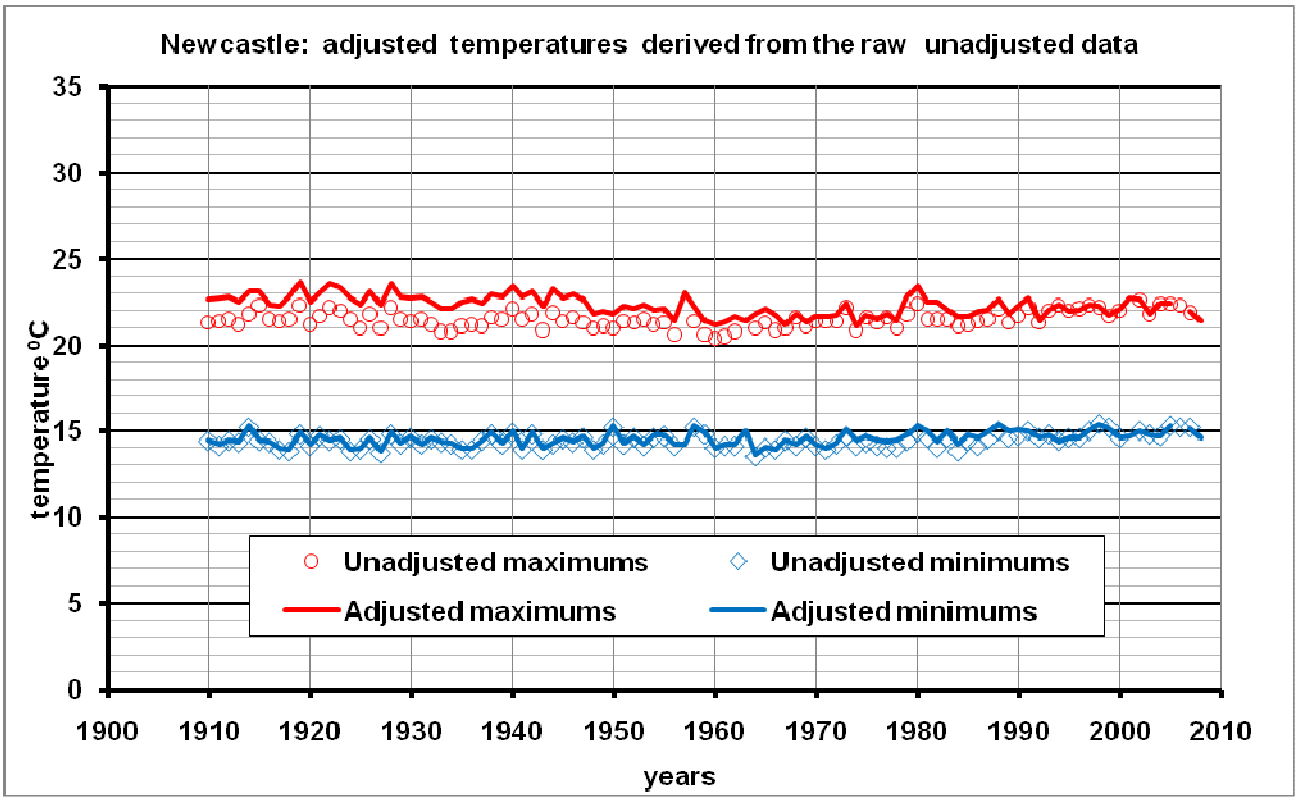
CASE STUDY: Global Warming – the forest from the trees

6. A graphical analysis of the long term temperature data for Newcastle.

Nobbys' Signal Station (BOM No. 061055) in Newcastle provides the Central Coast of NSW with its nearest long term temperature record apart from the one at Sydney Observatory. Over the next few pages we will use this temperature record in order to examine the way our perception of long term trends in climate are influenced by different forms of data treatment and graphical presentation and to improve our skills in drawing scientific inferences from such datasets.

ACTIVITY: The effect of Quality Control adjustment of a data time-series

Long-term sequences of annual temperature means, such as those presented in the graph below, are known as time-series. This graph shows time-series for the period 1910 to 2008 for both the raw data (*BOM, 2009 b*) and for the High Quality (i.e. adjusted) data (*BOM, 2009 c*). Examine carefully the graph below and answer the questions that follow.



QUESTION:

1. *Between 1910 and 1990 which of the two unadjusted time-series (maximum or minimum) required the greater amount of adjustment to produce the High Quality Dataset? What about after 1990?*
2. *According to the 'metadata' (i.e. documentation about the circumstances of measurement) for the Newcastle station, in 1989 the Stevenson Screen containing the thermometers was shifted to a new improved, position (less enclosed by buildings). Based on the above graph, what effect did the poor position of the Screen before 1990 have on the recorded maximum temperatures?*

EXTENSION:

*Do you think that the production of a High Quality Temperature Dataset (as shown here for Newcastle and described in detail for Sydney, Mildura and Boulia in **Appendices 3, 4(a), 4(b) and 4(c)**) is likely to have increased or to have decreased the validity of any inferences about Global Warming that might be drawn from the long term temperature measurements for these locations? Give reasons for your answer.*

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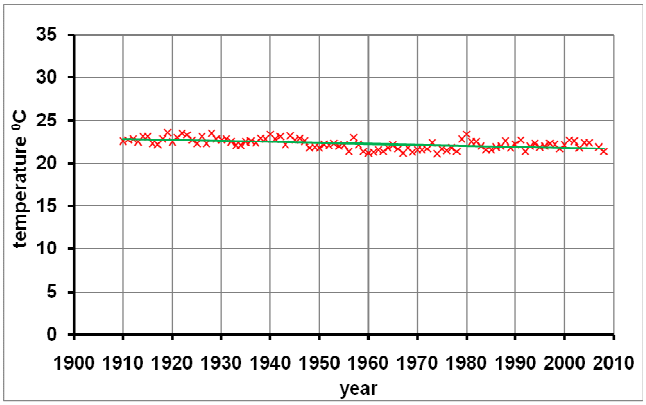
6(a) Effect of a change of scale

The graphs below present the same High Quality Dataset for Newcastle (*BOM, 2009 c*) but in two quite different formats. On the left hand side, the maximum and minimum data are presented on separate graphs (**1(a)** and **1(b)**) with the vertical axis displaying the broad range of temperatures (i.e. from 0^0C to 35^0C) likely to be encountered in the annual mean maxima and minima in eastern Australia. On the right hand side the same two data sets are presented (graphs **2(a)** and **2(b)**) with the vertical axis scaled in each case to a much narrower range of temperatures specific to the particular data being displayed (i.e. 20^0C to 24^0C for the Newcastle annual maximums) and (13^0C to 17^0C for the Newcastle annual minimums).

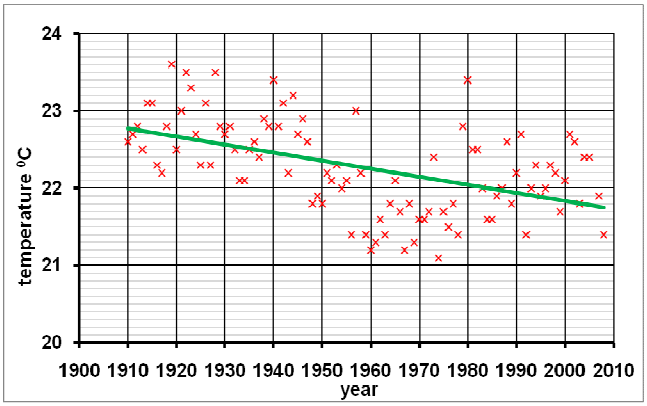
Another new feature of these four graphs is that in each case a 'line of best fit' (achieved by 'least squares linear regression') has been fitted to each set of data. This enables the overall trend in the individual time-series to be observed (see **Appendix 5** in the separate **Appendices** document).

ACTIVITY: The effect on our perceptions produced by a change in the scale of a graph

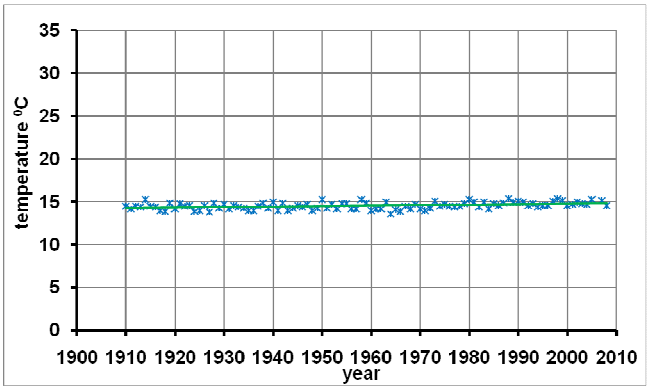
Examine carefully the four graphs below and answer the questions that follow.



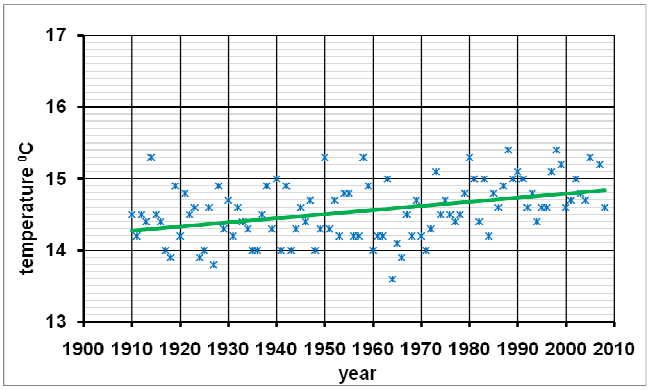
1(a). Adjusted maximums on a scale of 0 – 35 ^{0}C



2(a). Adjusted maximums on a scale of 20 – 24 ^{0}C



1(b). Adjusted minimums on a scale of 0 – 35 ^{0}C



2(b). Adjusted minimums on a scale of 13 – 17^{0}C

QUESTIONS:

1. *Describe the effect on your **perception** of the variability in the datasets, produced by the change in scale of the vertical axis between the graphs on the left and the graphs on the right.*
2. *Describe the effect on your **perception** of the overall trends in the maximum and minimum time-series, produced by the change in scale of the vertical axis.*
3. *Is there any **real** difference in the overall maximum temperatures trends between graph **1(a)** and graph **2(a)**? Explain.*
4. *Does there appear to be a **real** difference in the overall trend over time between maximum and minimum temperatures? Describe the difference.*

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6(b) The value of an anomaly

For detecting changes in temperature over time, especially where data from different Stations are to be compared and combined into regional, national or even global averages, meteorologists have found that the actual temperature values are less useful than so called temperature **anomalies**.

At present, the way these anomalies are calculated is like this:

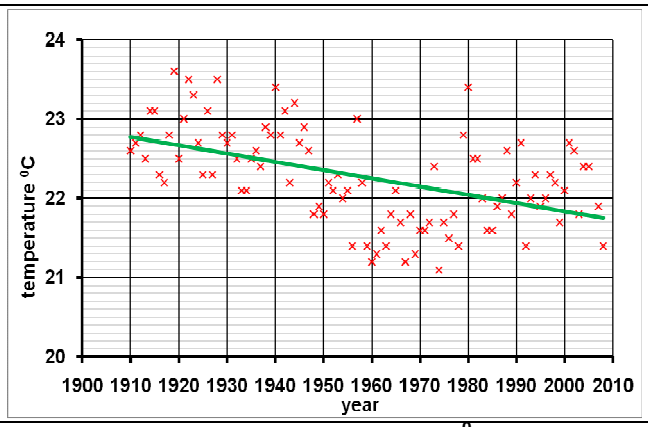
1. For any particular time series (take for example the Newcastle High Quality Annual Maximum Temperature series) we first calculate the mean across the whole 30 year of values for the period 1961 to 1990 This mean value is known as the "*station normal*"
2. We then subtract this 30-year "*station normal*" from each of the individual values in the time series in order to obtain a new time-series such that each element in the time-series is now expressed as a departure (i.e. an anomaly) from the 30 year base period average.

See **Appendix 6** in the separate **Appendices** document for a more detailed explanation of this procedure.

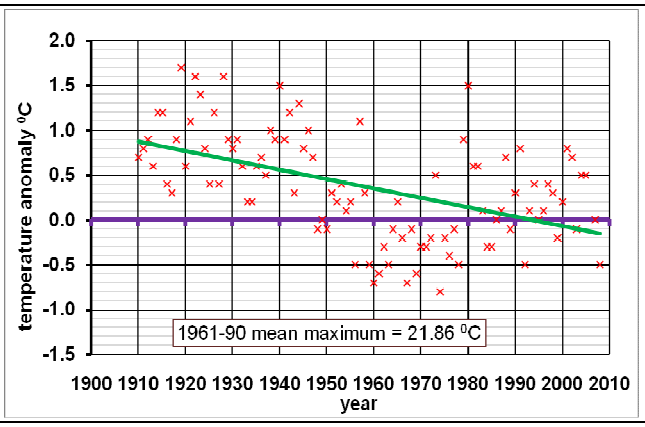
Because it is a period of time with good global data coverage, the period 1961-1990 has been chosen as the current international standard period for these calculations. Meteorological stations on land are often at different elevations, and different countries estimate average monthly temperatures using different methods and formulae. When combining data from different stations, the expression of temperatures as anomalies helps to avoid biases that could result from these problems.

ACTIVITY: The effect of expressing temperature data as anomalies

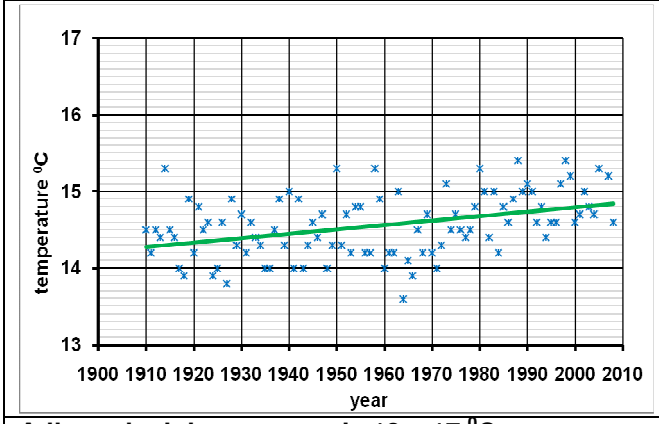
Examine these four graphs of the Newcastle dataset (*BOM, 2009 c*) and answer the questions.



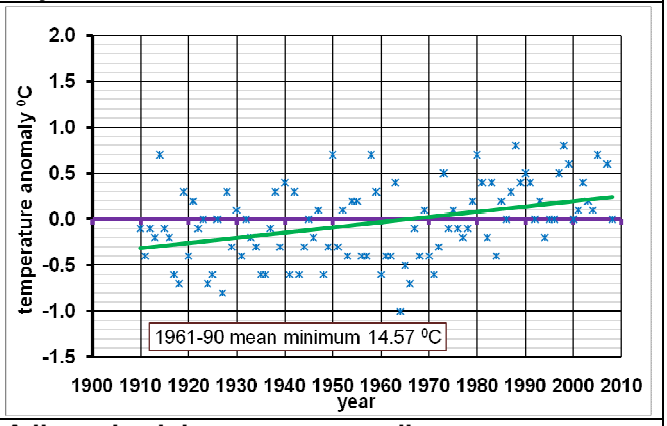
Adjusted maximums - scale 20 – 24 ^{0}C



Adjusted maximums as anomalies



Adjusted minimums - scale 13 – 17 ^{0}C



Adjusted minimums as anomalies

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QUESTIONS:

1. *Has the expression of temperatures as anomalies produced any alteration in the general trend of the lines of best fit and in the scatter of data points around the lines of best fit?*
2. *Describe one advantage that has resulted from expressing the Newcastle maximums and minimums as anomalies rather than as actual temperature values.*